Abstracts

Poster: 0116

An Experimental Model for Studying the Biodynamic and Physiological Effects of Vibration

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Exposure to upper limb vibration through the use of powered hand tools puts workers at risk for developing hand-arm vibration syndrome (HAVS). HAVS is characterized by cold-induced vasospasms in the digits and hands and reductions in tactile sensitivity, grip strength and manual dexterity. Although numerous studies have described the pathological changes in tissues from workers with HAVS, the mechanisms underlying these changes are unclear. Models exposing rat tails or limbs to vibration can be used to determine what mechanisms underlie vibration-induced tissue injury. However, because the physical response of tissue to vibration (i.e., biodynamic response) is dependent upon the morphology of the tissue, it is not clear if vibration has similar effects on rat and human tissues.

Goal: To measure the biodynamic response of rat tail tissue to different vibration frequencies and magnitudes, and the effects of vibration on tactile sensitivity and gene transcription to determine if the physiological responses of tails are similar to the responses of human fingers.

Methods: The effects of different vibration frequencies (31 – 500 Hz) and magnitudes (10 – 100 m/s2 r.m.s.) on the amplitude of the tail vibration were measured using a laser vibrometer. Each adult male rat was exposed to all frequency/magnitude combinations during a single bout of vibration. Changes in sensory nerve function in the tail were measured after exposure to a single 4 h bout of vibration (125 Hz, 45 m/s2 r.m.s.) using the current perception threshold (CPT) method and RT-PCR.

Results: The frequency and magnitude dependent biodynamic responses of rat tails to vibration were similar to those displayed by human fingers. Exposures to frequencies between 63-250 Hz amplified the biodynamic response of the tail (1.3 to 2.5 fold frequency dependent increase over the input amplitude). Increasing the magnitude did not alter the frequency dependent response of the tail, but did amplify the magnitude of the tissue response. Exposure to a single bout of vibration at 125 Hz also resulted in a 19% reduction in the sensitivity of large myelinated fibers to stimulation. The reduction in sensitivity was associated with a 4-fold reduction in nitric oxide synthase-1(NOS-1) and a 2-fold increase in calcitonin-gene related peptide (CGRP) transcript levels in nerves, factors critical in mediating pain and blood flow.

Based on these findings, we conclude that the rat tail serves as a good model for determining how changes in the biodynamic responses of tissue to vibration lead to tissue injury and alterations in sensory function. These findings also demonstrate that the non-invasive CPT method can be used to identify vibration-induced changes in sensory nerve fiber function.

Significance: Over 1 million workers in the construction, mining, agriculture and manufacturing sectors are regularly exposed to upper limb vibration. Epidemiological studies indicate that approximately 50% of these workers may develop HAVS. Using the rat tail model to uncover mechanisms underlying vibration-induced injury will provide information about what aspects of a vibration exposure are most injurious so that equipment and products can be respectively engineered or altered to reduce injury. In addition, this information can be used to develop new diagnostic and assessment methods to identify vibration-induced injuries before they result in permanent damage to vascular and neural tissues.

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